

Weather Note

TORNADOES DURING HURRICANE CARLA AT GALVESTON

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1. INTRODUCTION

There have been few observations, by radar, of tornadoes at less than 5-mi. range. The tornadoes which occurred at Galveston, Tex., during hurricane Carla [1], September 12, 1961, presented one of those rare chances. The purpose of this note is to present the radar operator's observations.

With the Weather Bureau's WSR-57 radar¹ the 0.5 μ sec. pulse length makes it possible to have a resolution of 246 ft., i.e., a point object will appear to be 246 ft. in depth. All the observations to be described were made with the radar operating in this short-pulse configuration. Because of the close proximity of the tornadoes to the radar antenna and of the large amount of hurricane-related precipitation, it was necessary to reduce the receiver gain until only the hardest, strongest echoes could be detected. With the receiver gain thus reduced and the antenna elevated, little could be seen beyond 15 n. mi.; therefore, the sweep expansion on the main PPI scope was used to enlarge the scale for maximum definition of the echoes.

2. OBSERVATIONS

The tornadoes in the Galveston area during Carla occurred in the outer periphery of the storm, along one of the more intense spiral bands (fig. 1) on the morning of September 12, 1961. With the 15° spiral overlay, this band could be followed into the center of the hurricane, 150 n. mi. to the west, near Austin, Tex. The direction of motion of the tornadoes was along the line, from south to north, along an azimuth of about 14°. The approximate tracks of four tornadoes in the Galveston area are shown in figure 2.

The first tornado occurred at approximately 0230 CST in La Marque, some 12 n. mi. northwest of the Galveston radar. This tornado was apparently small; it was not reported to the Weather Bureau at the time of occurrence nor was it observed on the radar.

The second tornado was detected on the WSR-57 shortly after 0300 CST. The radar revealed the hook

echo over the water, 4 n. mi. south. Since the period between the time it was first observed, by radar, and the time it struck the island, was less than 5 min., warnings could not be issued in advance. Warnings of tornadoes in the vicinity were issued immediately and everyone was advised to remain in whatever shelter he might presently be in and not to seek other shelter. The danger from high water and live wires during the darkness was as great as the danger of tornadoes; the tide was near 9 ft. with much of the island inundated. This tornado was recorded on the 16-mm. time lapse film in the frames

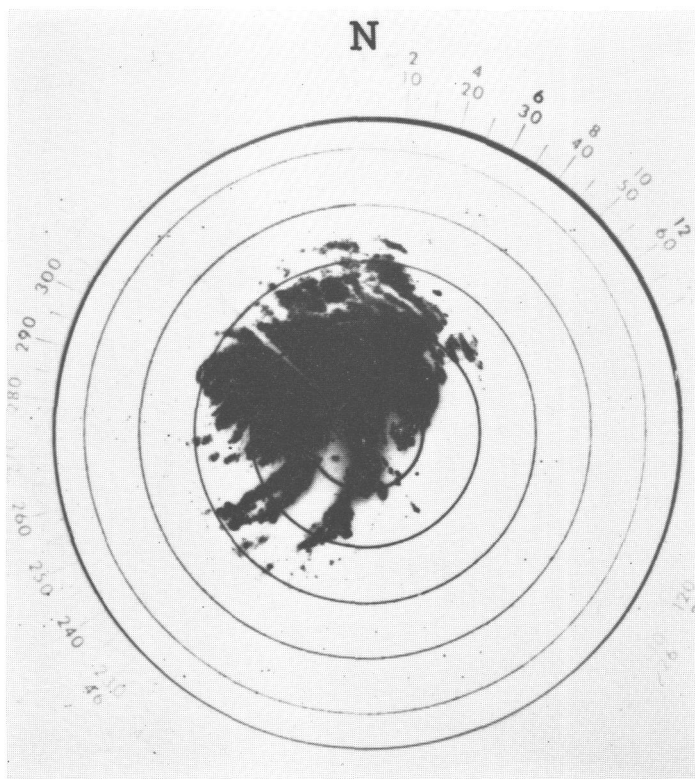


FIGURE 1.—Overall view of Carla as seen by Galveston radar at 0433 CST, September 12, 1963. Range circles are at 50 n. mi. with center of hurricane 150 n. mi. to the west. Spiral band with which the tornadoes were associated can be seen passing over the station.

¹ The WSR-57 is a 10.3-cm. wavelength radar, with a beam-width of 2.2° at the half power points, a pulse length of 0.5 μ sec. when operated on short pulse, and a pulse repetition frequency of 658 pulses per sec. on short pulse.

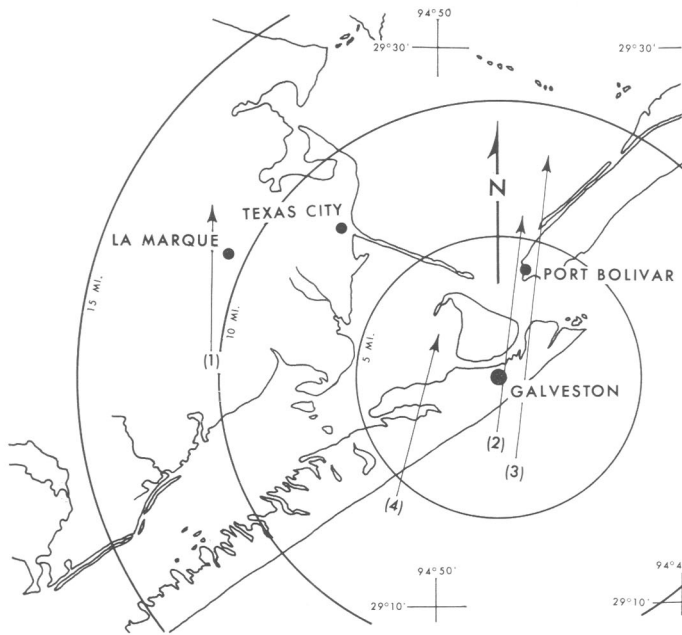


FIGURE 2.—Approximate ground tracks of the four local tornadoes during hurricane Carla, September 12, 1963: (1) La Marque at 0230 CST, (2) Galveston 0305 CST, (3) Galveston 0400 CST, (4) Galveston 0630 CST. Length of arrows does not reflect exact ground distance.

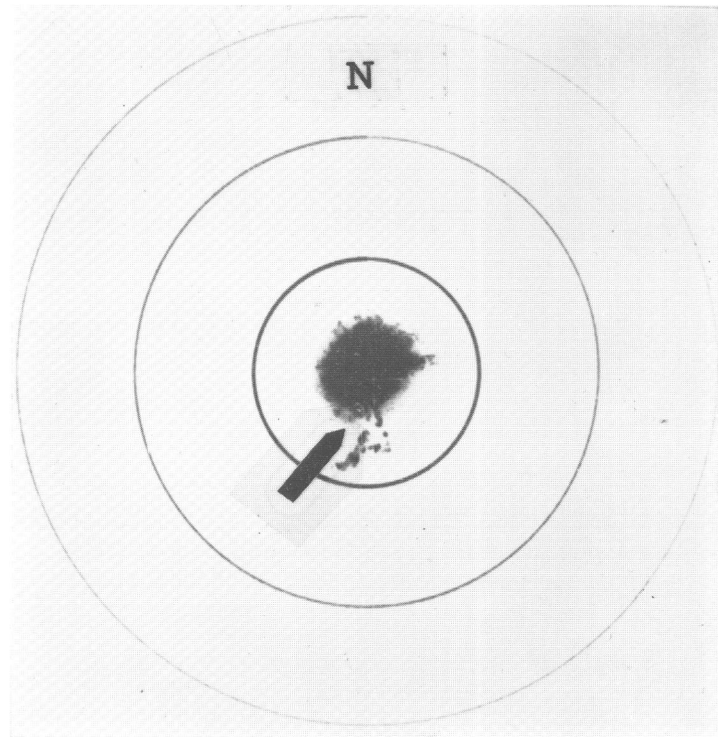


FIGURE 4.—Radarscope at 0359 CST. Funnel of third tornado is at edge of "clutter" (see arrow). Radar settings as in figure 3.

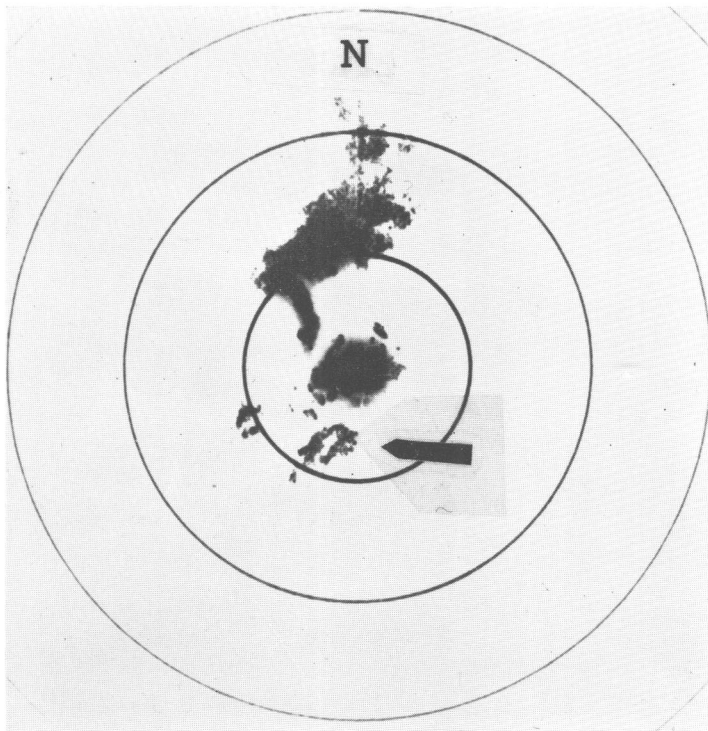


FIGURE 3.—Radarscope at 0303 CST. Arrow points to position of funnel of tornado no. 2. Range circles are at 5 n. mi; antenna was elevated 6°, and gain reduced minimum of 36 db.

from 0302 to 0310 CST September 12. At the time of figure 3, 0303 CST, the actual tornado is believed to have been at 197° and 3.5 n. mi. (see arrow). The appendage pictured to the northwest was from the parent cell, located almost due north, and was passing above the radar beam to the west and forming the funnel at 197°.

A word of explanation is probably justified here for the benefit of those who might doubt observation of the actual funnel. When this tornado touched the shore within 3 min. after the picture, it had a width of approximately 700 ft. at the ground level. This picture was taken with the antenna elevated so that the upper (wider) portions of the funnel are depicted and it appears elongated rather than circular because it was taken on the slant range.

This tornado passed within four blocks of the radar. It being night, there were no visual observations of this tragic tornado and it was some time, over half an hour, before its occurrence was verified. The path of the tornado was primarily over an almost completely evacuated residential area, as most of the residents who remained in the city had previously sought shelter in the larger buildings. There were seven deaths and property damage was very extensive.

The third tornado was also observed on the WSR-57. This tornado, recorded on the 16-mm. time lapse films

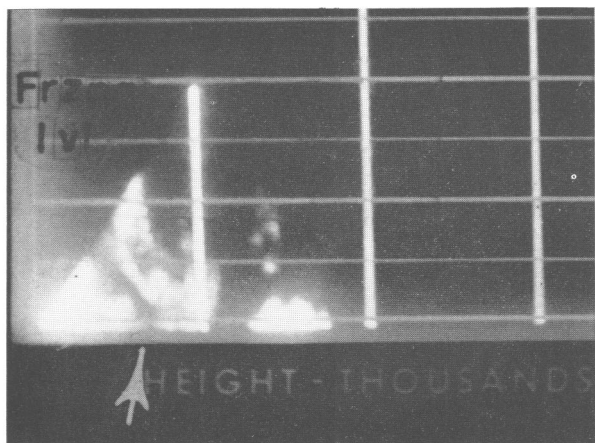


FIGURE 5.—Third tornado as seen on RHI scope at 0358 cst. Arrow points to funnel. Notice slant toward rear. Later, funnel was slanted almost 60° from vertical. Azimuth angle 190°, range marks at 5 n. mi.

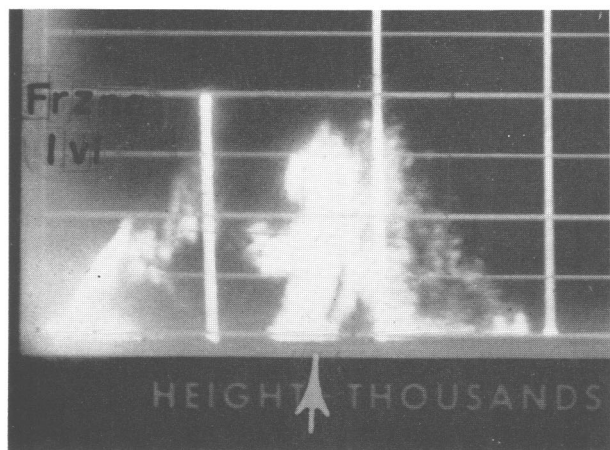


FIGURE 6.—Third tornado funnel on RHI scope at 0423 cst. Funnel had descended to surface after passing to north of radar. Azimuth angle 005°, range marks at 5 n. mi., maximum reflectivity at 14,000 ft.

in the frames from 0358 to 0406 cst, was first observed 20 min. before it struck the island, when it was still 8 mi. to the south-southwest. In figure 4 at 0359 cst, the funnel is shown at the edge of the ground clutter at 193° and 1.8 n. mi. (arrow). A careful examination of the Polaroid photograph shows the hole thought to be the core caused by centrifugal force, as described by Humphreys [2]. This hole was much more apparent on the PPI scope at the time of occurrence. When this tornado was less than 5 mi. away, it was thought from examination of the vertical structure on the RHI scope, to be lifting. A definite slant to the rear, at the surface, was observed (fig. 5). It was further observed by radar to make contact with the surface upon reaching the bay to the

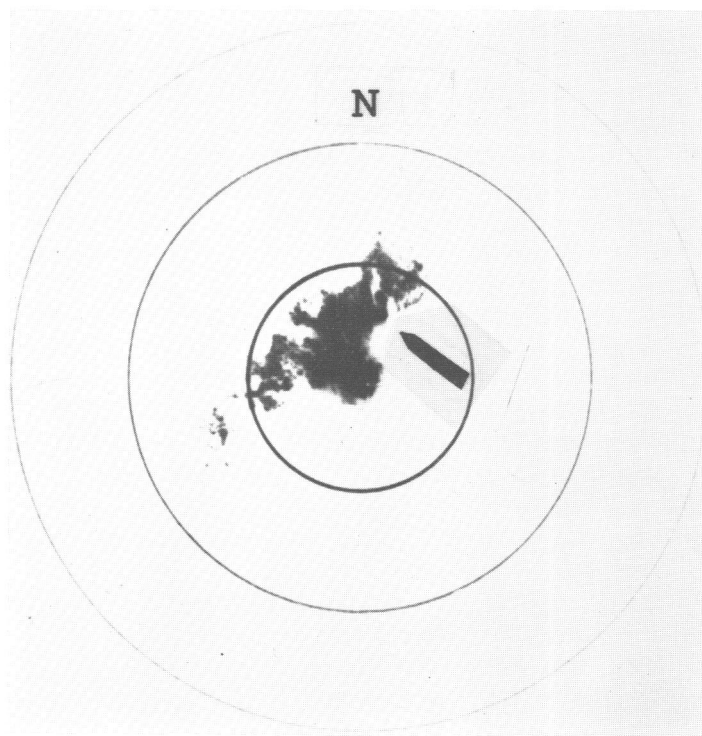


FIGURE 7.—Third tornado at 0405 cst, just 6 min. after figure 4. Arrow points to base of funnel. Range circles are at 5 n. mi.

north (fig. 6). The lifting and descending were later proven real; only the roofs of some structures were damaged as it crossed the island whereas many structures on Bolivar peninsula to the north were completely demolished. In figure 7, 0405 cst, the funnel is at 14° and 4 mi. At this point the funnel had regained surface contact and was beginning to pass across Bolivar peninsula.

The fourth tornado occurred about 0630 cst and was not observed on the radar. It was possibly larger than the other three; however, because of its location, it did less damage than the one noted shortly after 0300 cst. There were people in the sparsely populated area where it struck, but fortunately there were no injuries. It does not appear there were any witnesses to the actual funnel even though it was daylight.

The fifth tornado occurred about 1000 cst on the morning of September 12, at Port Arthur, as the same spiral band moved eastward to near the Texas-Louisiana border, about 75 mi. northeast of Galveston. This tornado was observed simultaneously on the Galveston and Lake Charles WSR-57's and the Beaumont WSR-1. Observations of this tornado were similar to the usual observations of tornadoes, with the familiar "figure six" hook. There was evidence, at the time, that other tornadoes occurred between 0300 and 0500 cst, but, since they occurred over water and during the hours of darkness, there was no way to verify their existence.

3. CONCLUSION

Although the heavy rainshield associated with hurricane Carla made tornado observation difficult, it was possible to detect and observe three of five reported tornadoes. Difficulty of observation was compounded in three instances because of the close proximity of the tornadoes to the radar antenna and the resulting need to reduce receiver gain and to elevate the antenna. It is postulated that tornadoes associated with this and other hurricanes may have escaped detection because of related gain, elevation angle, and beam distortion factors. In most instances radar personnel are most intent upon watching the overall hurricane activity and eye movement. The possibility of observing tornadoes within a 5-mi. radius of the radar and of precisely locating the vortex is very encouraging. It does not appear necessary to observe the entire

tornado cyclone [3] to establish the presence and position of the vortex when it is observed at close range. Heretofore, radar observations of tornadoes have been made at longer distances, rendering the vortex unobservable due to beam width stretching.

REFERENCES

1. Alexander Sadowski, "Tornadoes Associated with Hurricane Carla, 1961," *Monthly Weather Review*, vol. 90, No. 12, Dec. 1962, pp. 514-516.
2. W. J. Humphreys, *Physics of the Air*, McGraw-Hill Book Company, Inc., Third Edition, 1940, p. 226.
3. T. Fujita, "A Detailed Analysis of the Fargo Tornadoes, of June 20, 1959," *Research Paper* No. 42, U.S. Weather Bureau, Dec. 1960, 67 pp.

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